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Implications of respiratory syncytial virus seasonality for the timing of passive immunisation scenarios in Latin America and the caribbean – a cross-sectional modelling study

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ABSTRACT

Background: The variation in respiratory syncytial virus (RSV) seasonality presents challenges for the timing of RSV prophylaxis. Prevention policies must consider seasonal dynamics to protect infants from severe RSV infections. We evaluated the timing and impact of passive immunisation on birth cohorts in Latin America and the Caribbean, accounting for RSV seasonality, duration of protection and uptake.

Methods: We characterised the 2010–2019 RSV seasonality by climate region using a moving averages-based method and surveillance data and identified newborns eligible for passive RSV immunisation under varied assumptions of protection duration and strategies. Lastly, we explored different intervention time windows and estimated RSV-associated acute lower respiratory infections (ALRI) averted among newborns.

Findings: In 2010–2019, 28 countries reported 317,951 RSV-positive respiratory samples (12.6 % RSV positivity). RSV epidemics followed a south-to-north progression, with onset ranging from March to November in subtropical climates, and year-round epidemics in the tropics.

Seasonal immunisation benefited newborns born during January–September in temperate countries, while those born year-round in the tropics benefited from immunisation during at least one epidemic. Year-round vaccination covered newborns for at least one season; long-acting monoclonal antibodies (mAb) administered at five months to infants of immunised mothers extended protection through the remaining season. Year-round campaigns suited tropical climates.

At 80 % coverage, 61.3 % (95 % CI 60.7–67) and 55 % (95 % CI 55.0–56.0) RSV-ALRI cases among 0- < 12 months were averted through mAb in exemplar temperate and tropical countries, respectively. In subtropical countries, combined RSV maternal vaccination and long-acting mAb averted 57.3 % (95 %CI:56.8–57.8) of RSV-ALRI. Efficiency per 100,000 doses administered varied minimally across strategies.

Conclusions: RSV climatic variations underscored the importance of surveillance in tailoring the timing and extent of annual campaigns. RSV seasonality informs the selection of interventions. Public health initiatives can enhance prevention for newborns by defining optimal windows for immunising at-risk-infants.

1. Background

RSV poses significant morbidity and mortality in young children, particularly in those younger than 6 months. In the Americas, the incidence rate of RSV-associated acute lower respiratory infection (ALRI) ranged from 46.0 to 52.3 episodes per 1000 children under 5 years per year [1]. While treatment remains primarily supportive, preventing RSV-related severe outcomes in young infants is a public health priority.

The World Health Organization (WHO) Strategic Advisory Group of Experts on Immunisation recommends maternal vaccination and mAb to prevent severe RSV disease in infants [2]. Following technical guidance, long-acting mAb Nirsevimab was introduced in Chile, the USA, and Canada in 2024 [3–5]. Nirsevimab offers at least five months' protection against RSV-associated ALRI hospitalisations in newborns, though its high unit cost may limit feasibility without supporting economic evaluation [6,7]. The newly approved RSV prefusion F protein vaccine provides six months of protection via transplacental antibody transfer [8,9]. In 2023, the Pan American Health Organization's (PAHO/WHO) recommended RSV vaccination among pregnant individuals at 32–36 weeks gestation to prevent disease in infants and minimise preterm birth risk [10]. The United States, Canada, Argentina and Uruguay introduced immunisation, with broader regional access through PAHO's Revolving Funds [4,11–14]. Modelling single or combined strategies suggests seasonal immunisation is more cost-effective than year-round campaigns in temperate climates [4,15,16]. However, optimal timing in tropical settings with year-round circulation remains uncertain [17]. Effective adoption must consider local epidemiology, costs, health system capacity, and limited RSV immunisation duration of protection.

Local epidemiological data guide RSV prevention policy. In temperate countries, infants born near RSV seasonal onset face twice as likely RSV infection risk of those born at season's end [18,19]. Regional variability in RSV transmission patterns underscore the need for country-specific impact on birth cohorts as products emerge [20,21]. Annual RSV epidemics follow a climate-driven trend, with correlations between average climate variables or geographical location and timing of seasons [18,20,22–24]. Temperate countries experience winter seasonal RSV peaks, while the tropics show year-round circulation, with rainy summers and dry winters [23].

National surveillance systems within the SARInet Plus surveillance network integrated RSV to monitor transmission, document its role in respiratory hospitalisations and support vaccine impact monitoring [10,25]. Prevention policies must adapt to regional, seasonal dynamics to reduce severe RSV outcomes [26]. Yet decision-making on optimal timing and strategy in regions with year-round RSV circulation remains uncertain. We evaluated the hypothetical impact of RSV preventive strategies (maternal immunisation, mAb and a combined strategy) on different annual birth cohorts and RSV seasonal patterns, adjusting for the duration of protection in Latin America and the Caribbean (LAC) countries, and estimated cases potentially averted in newborns based on protection timing.

2. Methods

2.1. RSV surveillance by climate regions

This retrospective cross-sectional analysis in LAC used routinely-collected RSV national surveillance data from 2010 to 2019 from a multi-country integrated respiratory surveillance network, shared weekly throughthe PAHO/WHO platform for laboratory-confirmed respiratory virus [27]. Data were weekly totals of cases from patients meeting surveillance case definitions, with samples taken for respiratory viruses and a negative or positive laboratory result, through standardised testing protocols for influenza and RSV using molecular or immunofluorescence methods [27]. Standardised case definitions included Severe Acute Respiratory Infection (SARI: acute respiratory infection with a history of fever or measured fever of ≥38 °C and cough; with onset within the previous ten days, and hospitalisation), Acute Respiratory Infection (ARI: acute respiratory infection with shortness of breath, cough, sore throat, coryza) and influenza-like Illness (ILI: measured fever of ≥38 °C and cough; with onset within previous ten days) [28,29]. We excluded datasets with less than three RSV seasons and classified those remaining as "sentinel" or "universal", based on sentinel or universal surveillance source. Sentinel surveillance involves year-round, systematic sampling and testing of SARI and ILI cases, while universal surveillance captures routine RSV testing of SARI/ILI/ARI patients in non-sentinel healthcare settings not intended for surveillance. All data were de-identified before reporting to regional platforms. Countries were classified by climate (tropical, subtropical, or temperate) and hemisphere (Northern -NH- or Southern -SH-) based on latitude from national weather stations data (GSODR R package) [30]. Climate

Table 1
- Characteristics of available RSV preventive strategies.

	1st Strategy	2nd Strategy	3rd Strategy	
Immunoprophylactic products against RSV	Long-acting mAb (Nirsevimab)	RSV maternal Vaccine	Long-acting mAb (Nirsevimab)	RSV maternal Vaccine
Eligibility or target population	All infants up to 24 months	All pregnant women	All infants	All pregnant women
Suggested timing of administration	Within RSV season	Year-round	Within RSV season	Year-round
Administration schedule	One dose	One dose	One dose	One dose
Age of immunisation	Within-season birth. 1–6 months of age at season's start	3rd trimester of pregnancy	Within-season birth. 1–6 months of age at season's start	3rd trimester of pregnancy
Duration of protection	5–6 months	6 months	5–6 months	6 months
Efficacy		82 % (95 %CI: 56.8 %–92.4 %)**		
Effectiveness	90 % (95 %CI: 75 %–96 %)*			
Combined effectiveness****			84.1 % (95 %CI: 75.0 %–93.11 %)	

Note: High-risk infants included newborns with a history of prematurity, bronchopulmonary dysplasia or hemodynamically significant congenital heart disease who are ≤24 months or younger at the beginning of an RSV season. *Nirsevimab effectiveness and the respective standard error (se = 0.054) were obtained from Molinet et al. [6] against RSV-associated hospitalisation of acute respiratory infections. Nirsevimab offers protection for at least five months to newborns entering their first RSV season with 70.1 % efficacy against medically attended RSV-associated ALRI [7,50] and 90 % early effectiveness against RSV-associated hospitalisations of acute respiratory infections (ARI) [6]. ** RSV Maternal vaccine efficacy and its respective standard error (se = 9.082) were obtained from Madhi et al included in Zeng et al. metanalysis [8]. ****Combined effectiveness (VECC): To calculate the combined VECC, we employed a weighted average meta-analytic approach using an inverse-variance weighting, based on individual VE estimates from the literature (Supplementary Table 1). The combined effectiveness was determined by summing the products of each VE estimate and its corresponding weight, divided by the total sum of weights, with confidence intervals at 95 % calculated using the combined standard error (See Supplementary materials, method section).

was classified as temperate if the country's geographical centre's latitude was ≥|30°|, subtropical if |23.6°-29°| latitude, and tropical if ≤|23.5°| [31].

2.2. Assessment of RSV seasonal epidemics

We applied the WHO Average Curve Method [28,32,33] to 26 national datasets of weekly RSV percentage positive to model seasonality. The "average epidemic curve", calculated as a 3-week moving average centred on the season's median peak week, based on the historical average [28,33]. The "epidemic threshold", signalling the season's start and end, was defined as the median weekly value across all weeks (or mean, if the median was zero). Epidemiological Week (EW) was used to define key metrics. The onset EW was the first of two or more consecutive weeks with RSV activity above its seasonal threshold, and the offset EW, the first of two or more consecutive weeks with RSV activity below its seasonal threshold. Epidemic duration was calculated as total number of weeks between onset and offset, and the epidemic peak was the week with the highest viral activity during the annual season.

We explored annual RSV epidemics by climate region, defining multiple epidemics in a country of at least four EW with RSV activity below the seasonal threshold, separating consecutive epidemic periods. Sensitivity analysis of seasonality was performed using the Moving Epidemic Method (MEM), available as an application and R package [34,35].

2.3. Assumptions of RSV preventive strategies

We modelled the potential impact of RSV preventive products in three countries (Mexico, Paraguay, and the Dominican Republic) using a hypothetical analysis, estimating timing and burden reduction had maternal vaccination or long-acting mAb been introduced before 2020. Strategies included RSV maternal vaccine, long-acting mAb, and their combination targeting all newborns. Table 1 describes each strategy, including effectiveness, coverage and timing. Maternal vaccination administered at 32–36 weeks of gestation [10] confers passive RSV immunity to newborns, optimising transplacental antibody transfer before RSV epidemics [26]. Nirsevimab (long-acting mAb) was administered directly to all newborns during an RSV season, without requiring an immune induction period. A combined strategy involved sequentially administering maternal vaccination followed by long-acting mAb to the same high-risk infants born to vaccinated mothers, reflecting year-round RSV activity in subnational settings [36]. Long-acting mAb was given after theoretical six-month decline of maternal antibodies. We applied coverage assumptions from 100 % to 20 % of eligible birth cohorts during months at risk and estimated a combined vaccine efficacy to account for cumulative protection (See "Supplementary Methods"). Correlations between 2019 monthly births cohorts and RSV epidemics from three countries representing temperate, tropical and subtropical climates were also explored [37–39].

2.4. Cross-sectional retrospective modelling exercise on the timing of RSV preventive strategies

Using RSV seasonality estimates, we evaluated the timing and potential protection duration of RSV maternal immunisation and mAb strategies across monthly birth cohorts. In a cross-sectional retrospective scenario analysis, RSV seasonal patterns were combined with monthly births and assumed duration of protection (six months for maternal immunisation and five to six months for mAb) across countries by climate region (see Table 1).

We replicated the scenarios by country and climate regions, visualising outcomes for each preventive strategy alongside RSV seasonality. Figures displayed the expected birth month during RSV epidemics [26] and the potential duration of immunisation campaigns per monthly birth cohort. One representative country per climate region was used to assess potential maternal immunisation and mAb timing (Table 1), and three countries' monthly birth cohorts were explored to assess whether birth peaks align with RSV epidemic timing.

2.5. RSV burden averted in birth cohorts by climate region based on timing of interventions

We modelled the potential impact of three RSV preventive strategies in three countries, using a hypothetical analysis. Primary scenarios assumed 60 % coverage for maternal immunisation and 80 % for mAb; 100 % coverage was included as a theoretical maximum in sensitivity analysis. All strategies were evaluated at 20–100 % uptake, applying monthly coverage to susceptible newborn cohorts.

We assessed the proportion of RSV cases potentially averted by strategy and the corresponding efficiency in three national birth cohorts using retrospective RSV burden data. RSV-associated ALRI incidence risk among 0- < 12 months was extracted from Li et al. [1] for upper-middle-income countries (Dominican Republic, Mexico and Paraguay).

RSV-ALRI averted cases among infants aged 0- < 12 months and its proportion were estimated by summing, for each month, the product of the birth cohort covered, RSV incidence risk, intervention effectiveness, and coverage. Formulas and inputs are shown in Supplementary Table 1 and detailed in Supplementary Methods (pages 3–7). Intervention protection considered single and combined RSV products' effectiveness, derived by weighted average meta-analytic approach using inverse-variance weighting of individual studies [16](Table 1). The "birth month covered" was defined as the product of the monthly birth cohort and a "vaccine month "indicator (1=covered, 0=not covered), based on whether the expected protection period coincided with each country's RSV season. This identified the newborns protected by the intervention during epidemic months. We assumed log-normal distribution for incidence rates and risk were assumed lo-normally distributed, and effectiveness, efficacy and combined effectiveness normally distributed (See "Supplementary Methods").

$$\text{RSV Cases averted with intervention among } 0- < 12 \text{ months} = \sum_{\text{month}} (\text{Birth month covered x RSV incidence risk x Effectiveness or Efficacy x Immunisation coverage})$$

where:

$$\text{RSV} - \text{ALRI Incidence risk among } 0- < 12 \text{ months} = \frac{\text{Incidence rate RSV} - \text{ALRI among } 0- < 12 \text{ months}}{1000 \text{ population among } 0- < 12 \text{ months}}$$

$$\textbf{Percentage of RSV} - \textbf{ALRI Cases averted among } \mathbf{0- < 12 \text{ months}} = \frac{(\textbf{RSV Cases without intervention } \mathbf{0- < 12 \text{ months}} - \textbf{RSV Cases with intervention } \mathbf{0- < 12 \text{ months}})}{\textbf{RSV Cases without intervention } \mathbf{0- < 12 \text{ months}}} \textbf{ x 100}$$

We evaluated the efficiency of the three RSV preventive strategies (Table 1) by estimating the number of averted RSV-associated ALRI cases per dose administered and per 100,000 doses [40]. Efficiency was calculated assuming different coverages:

$$\text{Efficiency per } 100,000 \text{ doses administered} = \frac{\text{RSV Cases averted with intervention amonng } 0- < 12 \text{ months}}{\text{Number of doses administered to birth months eligible for prophylaxis}} \times 100,000$$

Eligible birth cohorts were defined as infants born during calendar months aligned with the seasonal protection window, and the number of doses corresponded to total covered births in those months.

For the 95 % confidence interval for RSV cases, proportions and efficiency metrics, we conducted 10,000-iterations Monte Carlo simulations, sampling from input parameter distributions (incidence risk and vaccine effectiveness) scaled to central point estimates (See "Supplementary Methods").

We utilised R Statistical Software [41] (v4.1.2; R Core Team 2021), Microsoft Excel and Tableau [42,43]. The research protocol was approved by ACCORD sponsor number AC19121 and the Pan American Health Organization Ethics Review Committee.

3. Results

3.1. RSV seasonal epidemics during 2010–2019 by climate regions

During 2010–2019, 28 countries and territories reported 317,951 RSV-positives from 2,516,582 (12.6 %) samples from respiratory cases, representing 4839 processed samples and 611 RSV-positive cases weekly. 26 LAC countries and territories reported 17.6 % of the total samples. 17 out of 26 LAC countries reported 10-year data. Belize and Jamaica (two years) were excluded. Southern Cone countries reported the highest number of RSV-positive cases (242,604).

By latitude, most countries presented a tropical climate. Subtropical zones included Brazil (Southeast and Central East), Mexico, and Paraguay; while Argentina, Chile and Uruguay represented the Temperate SH region. RSV seasonality progressed south-north (Fig. 1, Table 2), with RSV epidemic onset varying across and within climate regions, especially in the tropics.

RSV activity onset varied by subregion. Seasons began in March in Southern Cone countries, June in Andean countries, and late June in Caribbean countries, the earliest in Saint Lucia. Central American countries followed in July–August. Only tropical climate countries presented multimodal or year-round epidemics: Barbados, Colombia, Saint Lucia, Surinam, Trinidad and Tobago. Saint Lucia, Surinam and Trinidad and Tobago presented RSV peaks in January–February, April, June–July, and September; Barbados presented two waves (January and July–September).

In subtropical countries, RSV onset ranged from March (Southeast and Central East of Brazil, Paraguay) to November (Mexico), with seasons lasting 15 weeks (an equivalent of 3 to 4 months). Tropical climate countries had slightly longer epidemics (18 weeks, or 5 months). In Temperate SH countries, RSV activity occurred from March to June, averaging five months, with overall consistent onsets and durations across countries. MEM sensitivity analyses are in Supplementary Results.

3.2. Periods of protection from RSV infection using preventive strategies based on RSV season

We evaluated monthly birth cohorts to determine coverage attainable through four preventive strategies with different durations of protection and assessed their alignment with RSV patterns across different climates according to the timing and duration of the strategy. Additional evaluations for each country are detailed in the Supplementary results.

Temperate climate countries (Fig. 2c).

Nirsevimab with 6 months of protection. In temperate SH countries, seasonal administration benefits newborns born

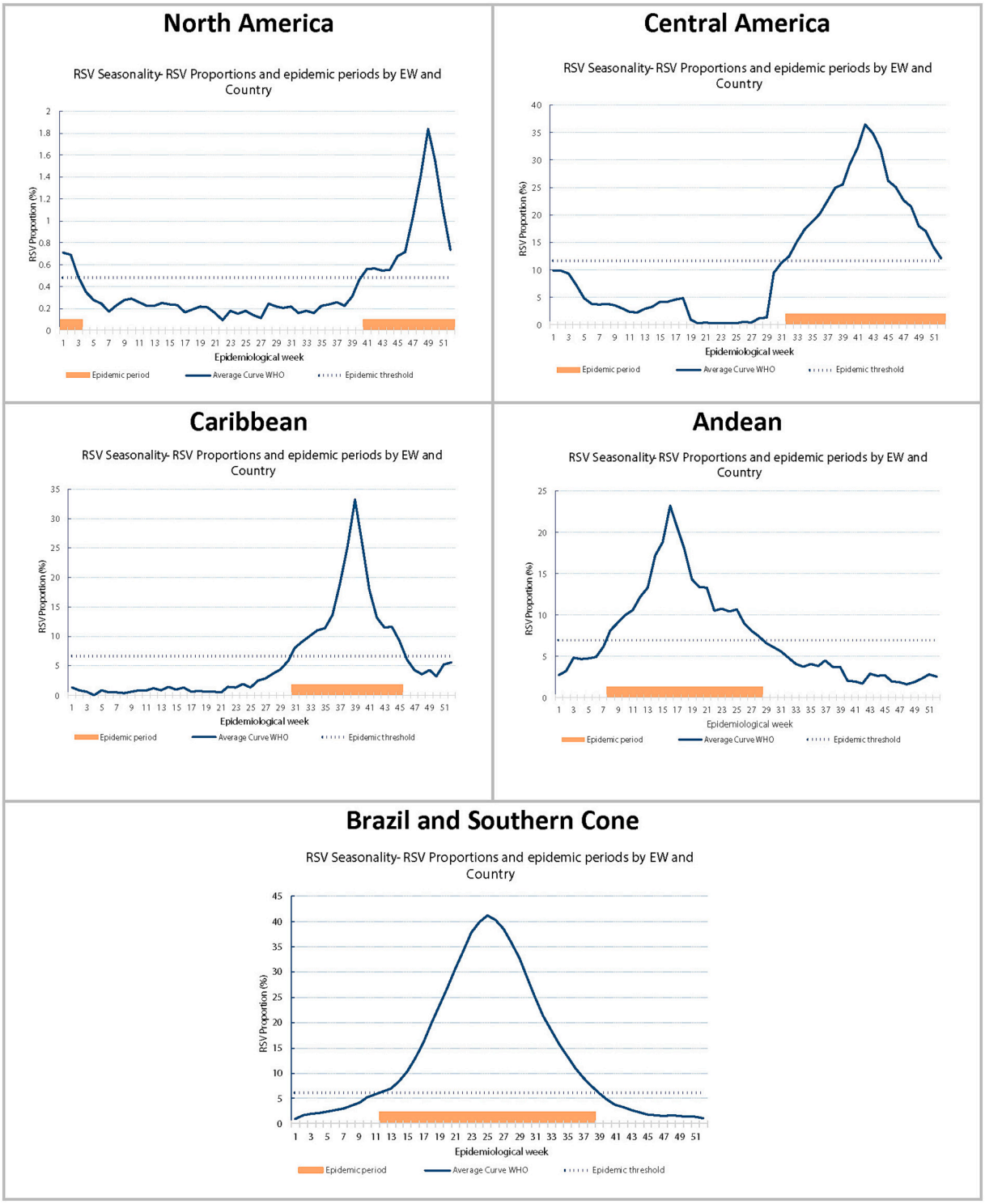

Fig. 1. – Distribution of RSV seasonal epidemics (represented by the average RSV percent positivity) by a country representative of each subregion, period 2010–2019. Region of the Americas.

January–September to align with the RSV season beginning in April. Birth cohorts born January–March alone, however, may not remain protected through the latter half of the season.

RSV maternal vaccine with up to 6 months of protection. Similarly, maternal immunisation benefits birth cohorts born January–September in the temperate SH countries, providing partial protection for January–March births during April-onset seasons.

Nirsevimab and RSV maternal vaccine with up to 6 months of protection each. Coverage was similar to individual strategies. While the schedule in Fig. 2a and d is similar to strategies 1 and 2, the difference lies in selecting newborns no longer protected by maternal immunisation to receive mAb during the rest of the season, or whose pregnant parent did not receive vaccine. All monthly birth cohorts, except those born during October to December for the SH, would potentially benefit from a combined strategy for the RSV season.

Tropical countries (see Fig. 2b).

Table 2
– Average RSV seasonality by climate regions, during 2010–2019 based on respiratory surveillance data, Latin America and the Caribbean countries.

Climate region	Country (and surveillance strategy)***	Average onset week	Average offset week	Average peak week	Average duration (in weeks)*	Modality (one vs multiple epidemics)**	Average RSV % positivity	Years of data	Latitude
Subtropical	Brazil (Southeast and Central East Regions)	9	14	11	5	Unimodal	0.9 %	2017–2019	−10.75
	Mexico	40	3	49	15	Unimodal	0.5 %	2010–2019	23.94
	Paraguay	11	31	20	20	Unimodal	14.5 %	2010–2019	−23.22
	Paraguay (SARI Sentinel)	11	30	20	19	Unimodal	18.5 %	2011–2019	−23.22
Tropical	Aruba	24	45	33	21	Unimodal	16.5 %	2015–2019	12.52
	Barbados	35	43	40	8	Multimodal	7.4 %	2010–2019	13.19
	Belize	40	7	45	18	Unimodal	5.7 %	2018–2019	17.19
	Bolivia	7	25	17	18	Unimodal	5.6 %	2010–2019	−16.71
	Bolivia - La Paz	7	27	16	20	Unimodal	8.1 %	2010–2019	−16.71
	Bolivia - Santa Cruz	12	30	22	18	Unimodal	2.6 %	2010–2019	−16.71
	Brazil (National)	4	22	14	18	Unimodal	1.5 %	2010–2019	−16.71
	Brazil (Northern Region)	13	33	23	20	Unimodal	8.7 %	2010–2019	−16.71
	Colombia	10	29	19	19	Multimodal	10.6 %	2010–2019	3.91
	Costa Rica	32	52	42	20	Unimodal	12.7 %	2010–2019	9.97
	Cuba	32	52	42	20	Unimodal	9.8 %	2010–2019	21.59
	Cuba (SARI sentinel)	32	49	41	17	Unimodal	16.7 %	2011–2019	21.59
	Dominican Republic	30	46	39	16	Unimodal	6.2 %	2010–2019	18.90
	Ecuador	51	18	9	20	Unimodal	8.9 %	2010–2019	−1.42
	Ecuador (SARI sentinel)	52	18	8	19	Unimodal	10.1 %	2011–2019	−1.42
	El Salvador	25	42	33	17	Unimodal	11.3 %	2010–2019	13.73
	Guatemala	23	47	33	24	Unimodal	3.6 %	2010–2019	15.70
	Honduras	29	51	40	22	Unimodal	9.3 %	2010–2019	14.82
	Jamaica	36	51	45	15	Multimodal	0.8 %	2018–2019	18.18
	Nicaragua	37	1	47	16	Unimodal	4.7 %	2010–2019	12.93
	Panama	30	52	41	22	Unimodal	21.8 %	2010–2019	8.51
	Peru	8	29	16	21	Unimodal	7.2 %	2011–2019	−9.14
	Saint Lucia	3	18	5	15	Multimodal	7.5 %	2015–2019	13.91
	Suriname	25	40	29	15	Multimodal	10.6 %	2013–2019	3.92
	Trinidad and Tobago	10	15	12	5	Multimodal	7.0 %	2015–2019	10.54
	Venezuela	29	48	42	19	Unimodal	2.8 %	2010,2011,2015–2019	7.12
Temperate South Hemisphere	Argentina	12	39	25	27	Unimodal	22.0 %	2010–2019	−35.40
	Chile	21	38	29	17	Unimodal	15.3 %	2011–2019	−38.19
	Chile (SARI Sentinel)	19	39	26	20	Unimodal	20.9 %	2011–2019	−38.19
	Uruguay (National)	17	38	27	21	Unimodal	1.4 %	2010–2019	−32.81

Note: The average RSV seasonality is represented by the resulting average epidemic curves obtained by country based on data analysed from 2010 to 2019 reported through Flunet from the SARI*Net* Plus multi-country network.

* Duration of the main or longer RSV epidemic in an average year, given a country with more than one RSV epidemic in an average year.

** Modality represents the number of average RSV epidemics in a year. The analysis of RSV data resulted in average RSV seasonality in countries with one epidemic or multiple (more than 1) annual RSV epidemics.

*** The Sentinel surveillance strategy for respiratory viruses in a country is a year-round routine system designed for standardised surveillance. It involves systematic sampling, procedures and testing protocols based on SARI and/or ILI case definitions. Additionally, the National surveillance strategy in a country includes routine non-sentinel testing for RSV in patients with SARI, ILI or ARI. This testing is primarily conducted in hospitals or ambulatory settings that are not specifically set up for surveillance purposes.

In tropical countries with multiple RSV peaks, intervention timing was aligned to protect all birth cohorts. RSV seasons in Trinidad and Tobago and Saint Lucia occurred in March–April, June–August, and November–December.

Nirsevimab with 6 months of protection. Birth cohorts born from January to December benefit from nirsevimab at least one RSV season. Earlier administration reduces protection during the subsequent RSV epidemics.

RSV maternal vaccine with up to 6 months of protection. Year-round maternal immunisation provides coverage for at least one RSV season. Nonetheless, infants born January–June may remain unprotected during November–December RSV epidemics.

Nirsevimab and RSV maternal vaccine with up to 6 months of protection each. Year-round maternal immunisation provides coverage for all birth cohorts for at least one RSV season, but infants born January–June may lack protection during the November–December RSV peak. Administration of nirsevimab at five months to newborns from immunised mothers can extend protection, with early-year cohorts potentially receiving an additional nirsevimab after six months to cover later-season epidemics.

Subtropical countries (see Fig. 2a).

Nirsevimab with 6 months of protection. In subtropical countries with RSV patterns similar to temperate SH climates, birth cohorts from January to August are targeted to align with the RSV season beginning in March. In subtropical countries resembling temperate NH, coverage mirrors NH monthly birth cohorts.

RSV maternal vaccine with up to 6 months of protection. Similarly, maternal immunisation would benefits the same January–August

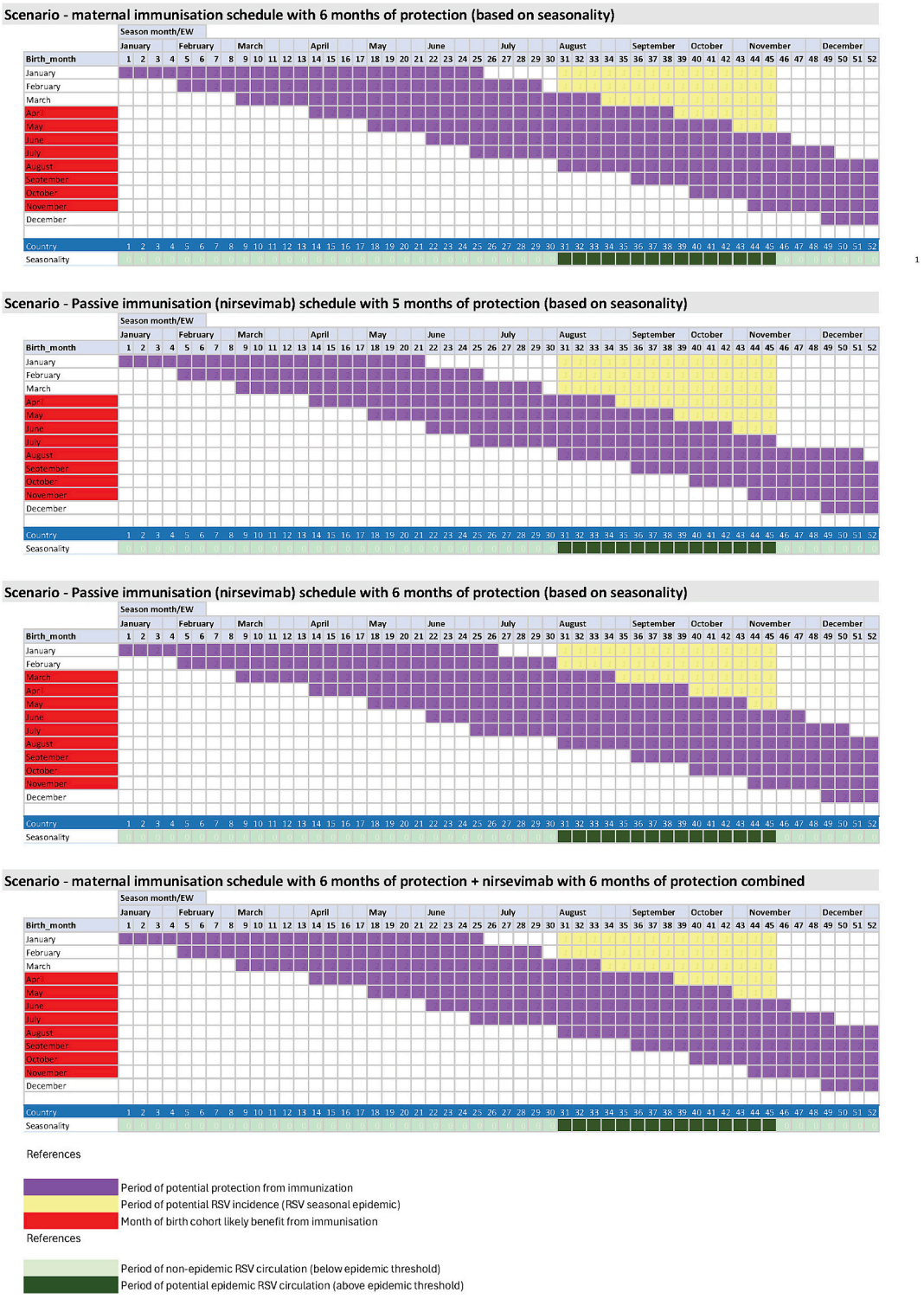

Fig. 2. a - Period of potential duration of protection from RSV infection using different immunisation strategies, for each country in the Region assuming each RSV seasonality (WHO Average curve methodology) – in a country with subtropical climate (b) - Period of potential duration of protection from RSV infection using different immunisation strategies, for each country in the Region assuming each RSV seasonality (WHO Average curve methodology) – in a country with Tropical climate (c) - Period of potential duration of protection from RSV infection using different immunisation strategies, for each country in the Region assuming each RSV seasonality (WHO Average curve methodology) – in a country with a Temperate Southern Hemisphere climate.

birth cohorts in SH-pattern subtropical countries.

Nirsevimab and RSV maternal vaccine with up to 6 months of protection each. Newborns from RSV-immunised mothers may potentially receive nirsevimab for the remainder of the RSV season, applied only if maternal immunisation coverage ended (see Fig. 2a and d).

3.3. *Timing for immunisation strategies by climate regions*

We assessed the hypothetical timing of maternal immunisation and mAb campaigns across four climate regions to optimise coverage of monthly birth cohorts.

In temperate SH countries, maternal vaccination targeted from November to June could confer transplacental immunity to monthly birth cohorts early in the RSV season, potentially reducing severe RSV infections (Fig. 3a). Alternatively, a nirsevimab campaign could be administered at birth from January through September to cover these cohorts. A combined schedule would vaccinate mothers November–June and provide nirsevimab June–September, extend protection as passive maternal immunity declines.

Subtropical countries with RSV patterns similar to temperate SH or NH regions, maternal vaccination from November to May, combined with a nirsevimab campaign through August, may be appropriate. In tropical countries with multimodal RSV seasons, year-round maternal immunisation and mAb campaigns from January to October could cover later RSV epidemics. Sensitivity analysis of monthly births versus RSV activity in three countries showed correlation of −0.45 (95 %CI: −0.7 -0.1), $P < 0.05$, with birth peaks aligning with RSV peak.

3.4. RSV burden averted in birth cohorts by climate region

Across the coverage scenarios, the number of cases averted, and doses administered decreased as coverage declined from 100 % to 20 %. The trends were consistent across the three strategies (Table 3). At 60 %

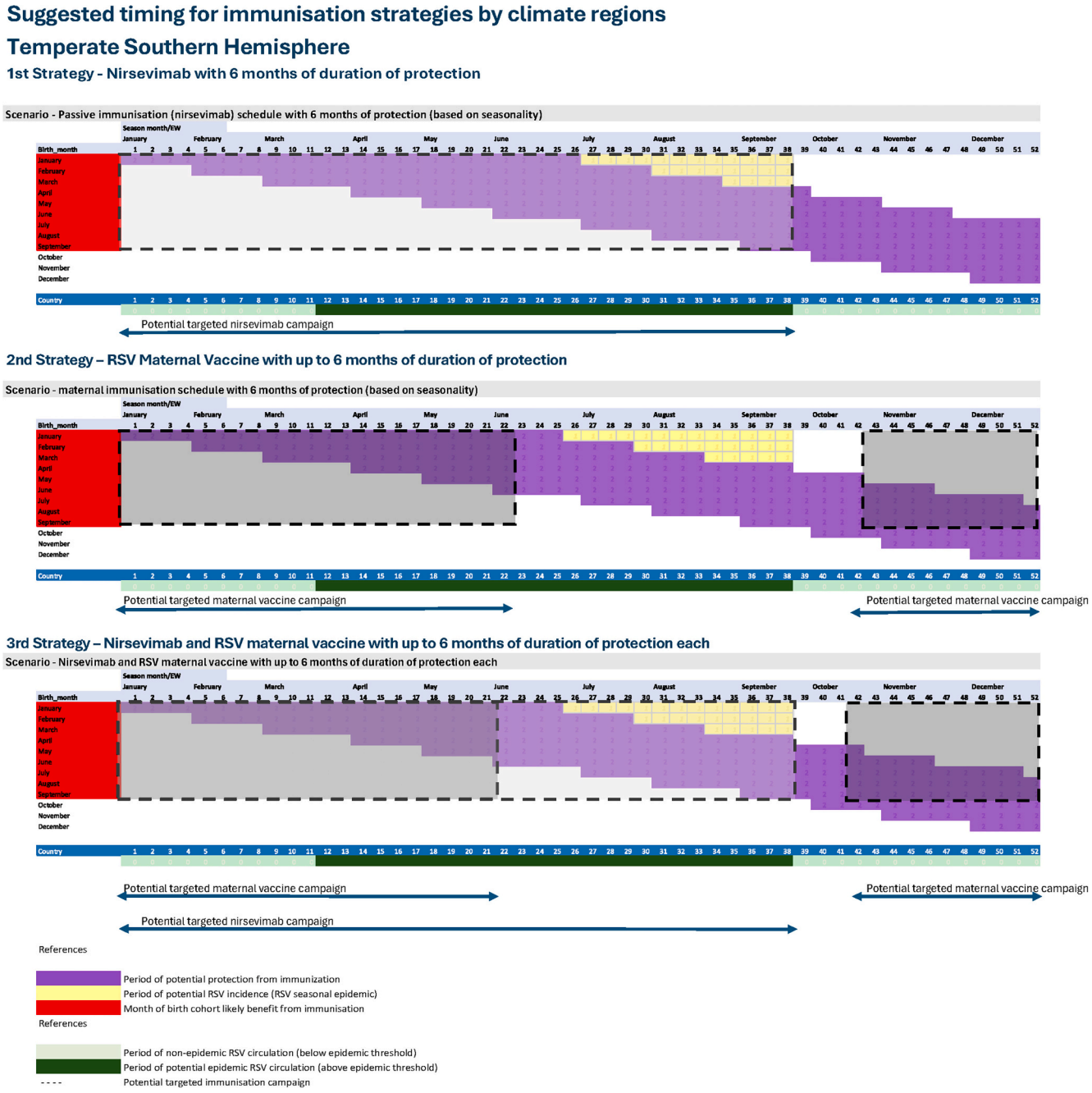

Fig. 3. a - Time of potential immunisation strategy by expected due date or cohort birth month, by a country's RSV seasonality in a Temperate Southern Hemisphere country (b) **-** Time of potential immunisation strategy by expected due date or cohort birth month, by a country's RSV seasonality in a Subtropical country (c) **-** Time of potential immunisation strategy by expected due date or cohort birth month, by a country's RSV seasonality in a Tropical country.
NOTE: *Assuming a 6-month protection from transplacental antibodies in newborn infants after RSV maternal immunisation. Doted box represents potential target immunisation campaign for pregnant women between 16 and 36 weeks gestation.
** Assuming a 4 to 6-month protection from passive antibodies in newborn infants targeted for monoclonal antibodies against RSV infection.

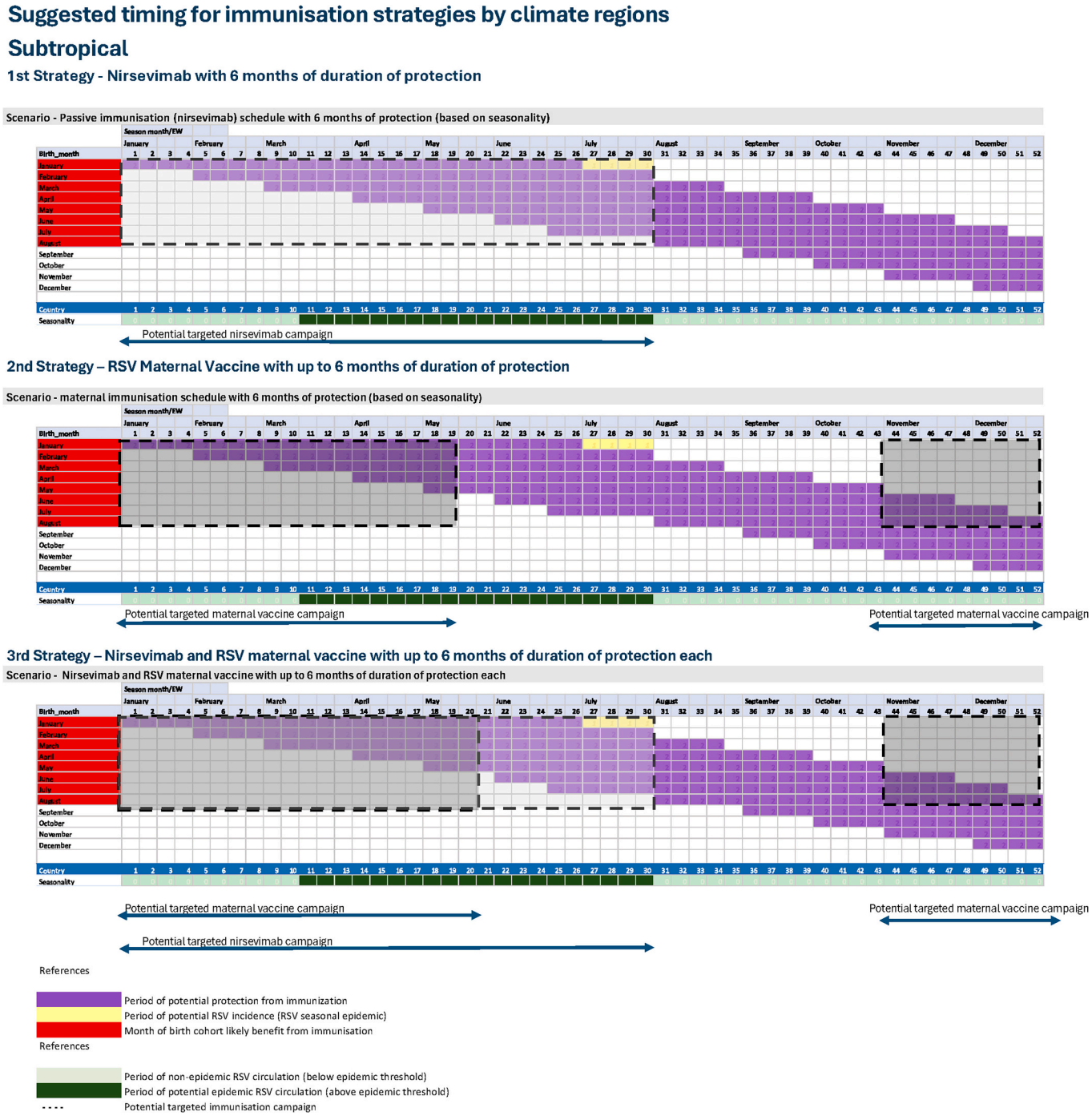

Fig. 3. (*continued*).

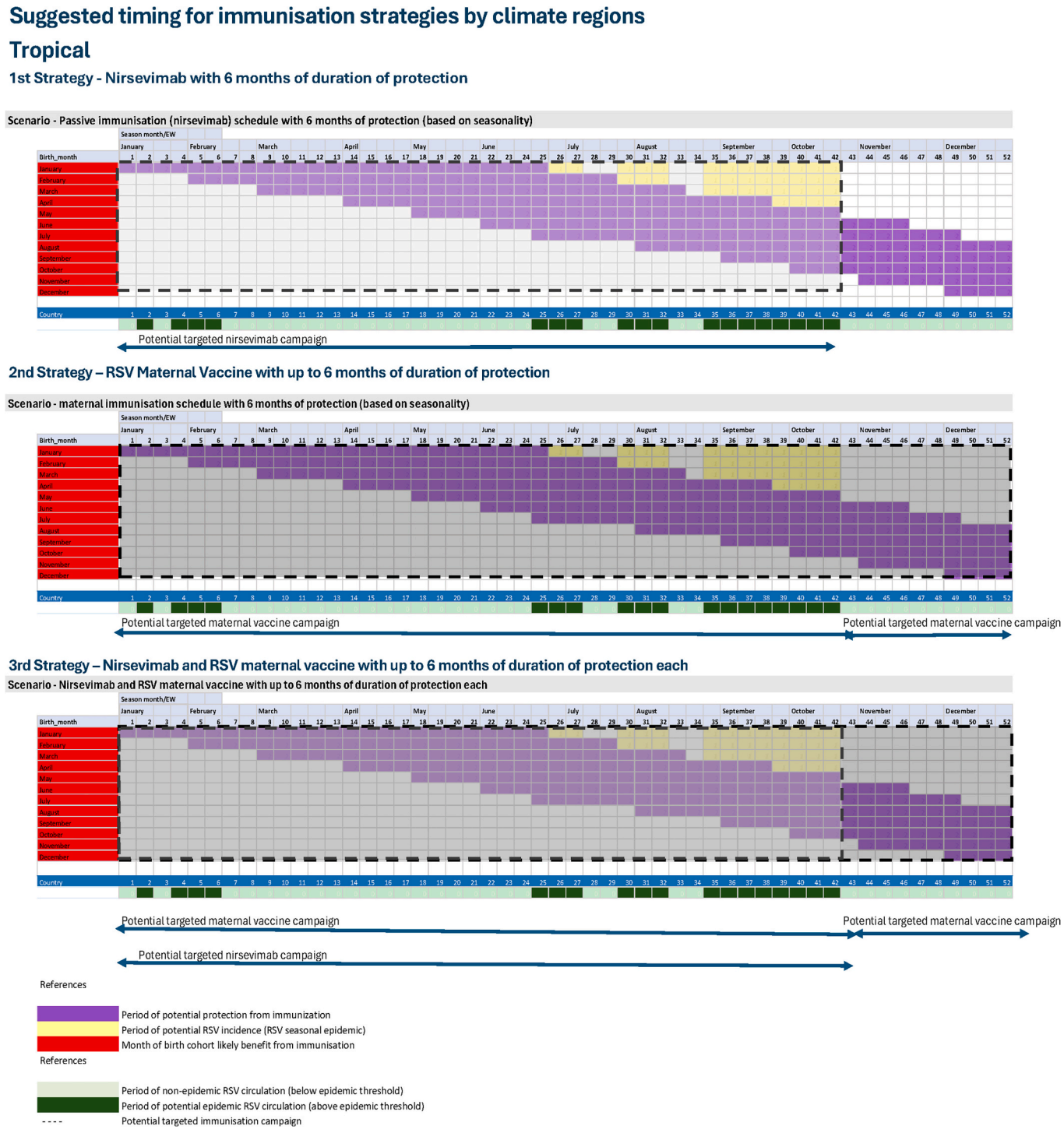

Fig. 3. (*continued*).

coverage, in Mexico, a predominantly temperate climate country, RSV maternal immunisation averted ~75,392 RSV-ARLI cases (95 %CI 58034–93,700) from 0 to <12 months in 2019. For 80 % uptake on the same population, Nirsevimab averted ~1,381,600 cases (95 %CI 106421–171,855), while the combined strategy of nirsevimab and maternal immunisation for the same newborn population resulted in ~105,540 (95 %CI 80684–131,239) averted cases.

Similarly, in Dominican Republic, tropical climate country, nirsevimab averted ~10,100 RSV-ALRI cases among the 0 to <12 months of age (95 %CI 7777–12,557) at 80 % uptake. For the same birth cohort, maternal immunisation averted ~6060 ALRI-RSV cases (95 %CI 4656–7523), and a combined strategy of RSV products resulted in 6370 (95 %CI 4888–7914) cases averted at 60 % uptake. Meanwhile, in Paraguay, a subtropical climate country, the same intervention combining nirsevimab and maternal immunisation to prevent severe RSV illness in newborns resulted in a total of ~3980 RSV-ALRI cases (95 %CI 3044–4944) averted and higher in comparison to the other interventions in the same population.

At 100 %, in temperate climates, 75.9 % (95 % CI 67–84.5) RSV-ALRI cases among 0- < 12 months were averted through nirsevimab, and 69 % (95 % CI 61.4–77.2), in tropical climates. In subtropical countries, the combination of vaccination and nirsevimab averted 71.6 % (95 %CI

Table 3
- Total RSV cases before and after the intervention, averted burden and efficiency per 100,000 doses administered by immunisation uptake scenarios, based on duration of protection and RSV seasonality for a subtropical, temperate and tropical climate country, 2019.

Country (Type of Climate)	Total Live births	RSV cases without intervention (95 % CI)	Intervention and duration of protection*	Immunisation Uptake	RSV Cases Averted (95 % CI)	RSV cases with intervention (95 % CI)	% of RSV cases averted (95 % CI)	Efficiency (per dose)	Efficiency per 100,000 doses (95 % CI)	Doses administered	Birth month covered vaccine**	Birth months eligible for prophylaxis
Mexico (Temperate Northern Hemisphere and Subtropical Northern Hemisphere)	2,092,212	227,633 (205,568; 250,211)	RSV Maternal Vaccine	100 %	125,653 (96,724; 156,166)	101,979 (78,550; 126,847)	55.2 (43.0; 67.2)	0.1	8704.0 (6700.0; 10,817.6)	1,443,627	1,443,627	January, June–December
				80 %	100,523 (96,724; 156,166)	127,110 (97,845; 157,976)	44.2 (43.4; 44.9)	0.1	8704.0 (6700.0; 10,817.6)	1,154,902		
				60 %	75,392 (58,034; 93,700)	152,241 (117,190; 189,210)	33.1 (32.7; 33.5)	0.1	8704.0 (6700.0; 10,817.6)	866,176		
				40 %	50,261 (38,689; 62,466)	177,371 (136,621; 220,443)	22.1 (21.9; 22.3)	0.1	8704.0 (6700.0; 10,817.6)	577,451		
				20 %	25,131 (19,345; 31,233)	202,502 (155,879; 251,676)	11 (11.0; 11.1)	0.1	8704.0 (6700.0; 10,817.6)	288,725		
			Nirsevimab	100 %	172,705 (132,700; 214,418)	54,928 (46,887; 63,554)	75.9 (67.0; 84.5)	0.0	9792.0 (7525.9; 12,151.2)	1,763,735	1,763,735	January–February, May–December
				80 %	138,164 (106,421; 171,855)	89,469 (76,261; 103,564)	61.3 (60.7; 67.0)	0.1	9792 (7542.3; 12,179.8)	1,410,988		
				60 %	103,623 (79,816; 128,892)	124,010 (105,508; 143,469)	45.5 (45.2; 45.9)	0.1	9792 (7542.3; 12,179.8)	1,058,241		
				40 %	69,082 (53,210; 85,928)	158,551 (134,896; 183,430)	30.3 (30.2; 30.5)	0.1	9792 (7542.3; 12,151.2)	705,494		
				20 %	34,541 (26,605; 42,964)	193,092 (164,586; 223,513)	15.2 (15.1; 15.2)	0.1	9792 (7542.3; 12,179.8)	352,747		
			RSV Maternal Vaccine + Nirsevimab	100 %	131,936 (101,749; 165,154)	95,697 (82,451; 110,295)	58 (51.7; 64.3)	0.1	9139.2 (7048.2; 11,440.2)	1,443,627	1,443,627	January, June–December
				80 %	105,549 (80,684; 131,239)	122,084 (82,451; 110,295)	46.4 (46.0; 46.8)	0.1	9139.2 (6986.2; 11,440.2)	1,154,902		
				60 %	79,162 (60,513; 98,429)	148,471 (127,633; 171,083)	34.8 (34.6; 35.0)	0.1	9139.2 (6986.2; 11,363.7)	866,176		
				40 %	52,774 (40,342; 65,620)	174,858 (150,316; 201,488)	23.2 (23.1; 23;3)	0.1	9139.2 (6986.2; 11,363.7)	577,451		
				20 %	34,541 (26,605; 42,964)	201,245 (82,451; 110,295)	11.6 (11.6; 11.6)	0.1	9139.2 (7021; 11,368)	288,725		
Dominican Republic (Tropical)	167,686	18,244 (16,465; 20,053)	RSV Maternal Vaccine	100 %	10,099 (7778; 12,561)	8146 (6227; 10,128)	55.4 (43.4; 67.3)	0.1	8704.0 (6704.3; 10,826.5)	116,022	116,022	April–November

(*continued on next page*)

Table 3 (*continued*)

Country (Type of Climate)	Total Live births	RSV cases without intervention (95 % CI)	Intervention and duration of protection*	Immunisation Uptake	RSV Cases Averted (95 % CI)	RSV cases with intervention (95 % CI)	% of RSV cases averted (95 % CI)	Efficiency (per dose)	Efficiency per 100,000 doses (95 % CI)	Doses administered	Birth month covered vaccine**	Birth months eligible for prophylaxis
				80 %	8079 (6207; 12,561)	10,165 (7811; 12,621)	44.3 (43.5; 45.0)	0.1	8704 (6687.8; 10,806.3)	92,818		
				60 %	6059 (4656; 7523)	12,185 (9365; 15,121)	33.2 (32.8; 33.6)	0.1	8704 (6687.8; 10,806.3)	69,613		
				40 %	4039 (3104; 5015)	14,205 (10,918; 17,627)	22.1 (22; 22.3)	0.1	8704 (6687.8; 10,806.3)	46,409		
				20 %	2020 (1558; 2528)	16,225 (12,466; 20,143)	11.1 (11.0; 11.1)	0.1	8704 (6712.5; 10,895.4)	23,204		
				100 %	12,649 (9722; 15,696)	5596 (4770; 6500)	69.3 (61.4; 77.2)	0.1	9792.0 (7525.9; 12,151.2)	129,174		
				80 %	10,119 (7777; 12,557)	8125 (6934; 9386)	55.5 (55; 56)	0.1	9792.0 (7525.9; 12,151.2)	103,339		
			Nirsevimab	60 %	7589 (5833; 9418)	10,655 (9095; 12,328)	41.6 (41.3; 41.9)	0.1	9792.0 (7525.9; 12,151.2)	77,504	129,174	March–November
				40 %	5059 (3889; 6278)	13,185 (11,255; 15,255)	27.7 (27.6; 27.9)	0.1	9792.0 (7525.9; 12,151.2)	51,670		
				20 %	2530 (1942; 3158)	15,714 (13,411; 18,152)	13.9	0.1	9792.0 (7518.49; 12,222.3)	25,835		
				100 %	10,603 (8142; 13,235)	7641 (6555; 8823)	58.1 (51.9; 64.4)	0.1	9139.2 (7017.3; 11,407.5)	116,022		
				80 %	8483 (6517; 10,551)	9761 (8396; 11,223)	55.5 (54.9; 56)	0.1	9139.2 (7021; 11,368)	92,818		
			RSV Maternal Vaccine + Nirsevimab	60 %	6362 (4888; 7914)	11,882 (10,211; 13,714)	41.6 (41.3; 41.9)	0.1	9139.2 (7021; 11,368)	69,613	116,022	April–November
				40 %	4241 (3258; 5276)	14,003 (12,033; 16,162)	23.2 (23.2; 23.3)	0.1	9139.2 (7021; 11,368)	46,409		
				20 %	2121 (1623; 2636)	16,124 (13,868; 18,538)	11.6 (11.6; 11.6)	0.1	9139.2 (6994.4; 11,361.7)	23,204		
				100 %	6312 (4826; 7849)	2947 (2264; 3659)	68.2 (53.6; 83.0)	0.1	8704.0 (6653.6; 10,822.6)	72,526		
Paraguay (Subtropical)	85,108	9260 (8358; 10,178)	RSV Maternal Vaccine	80 %	5050 (3895; 6322)	4210 (3246; 5269)	54.5 (53.7; 55.5)	0.1	8704 (6712.5; 10,822.6)	58,021	72,526	January–August, November–December
				60 %	3788 (2921; 4741)	5472 (4202; 6830)	40.9 (40.4; 41.4)	0.1	8704 (6712.5; 10,895.4)	43,516		

(*continued on next page*)

Table 3 (*continued*)

Country (Type of Climate)	Total Live births	RSV cases without intervention (95 % CI)	Intervention and duration of protection*	Immunisation Uptake	RSV Cases Averted (95 % CI)	RSV cases with intervention (95 % CI)	% of RSV cases averted (95 % CI)	Efficiency (per dose)	Efficiency per 100,000 doses (95 % CI)	Doses administered	Birth month covered vaccine**	Birth months eligible for prophylaxis
				40 %	2525 (1947; 3161)	6735 (5171; 8406)	27.3 (27; 27.5)	0.1	8704 (6712.5; 10,895.4)	29,010		
				20 %	1263 (976; 1575)	16,124 (13,868; 18,538)	13.6 (13.5; 13.7)	0.1	8704 (6725.6; 10,855.2)	14,505		
				100 %	5839 (4486; 7264)	3420 (2913; 3964)	63.1 (55.7; 70.3)	0.1	9792 (7522.5; 12,180.0)	59,635		
				80 %	4672 (3587; 5831)	4588 (3908; 5317)	50.5 (50; 51)	0.1	9792 (7518.5; 12,222.3)	47,708		
			Nirsevimab	60 %	3504 (2690; 4373)	5756 (4891; 6655)	37.8 (37.6; 38.1)	0.1	9792 (7518.5; 12,222.3)	35,781	59,635	January–July
				40 %	2336 (1788; 2904)	6924 (5883; 8006)	25.2 (25.1; 25.3)	0.1	9792 (7494; 12,222.3)	23,854		
				20 %	1168 (897; 1455)	8092 (6892; 9378)	12.6 (12.6; 12.6)	0.1	9792 (7519.4; 12,202.2)	11,927		
				100 %	6628 (5073; 8240)	2631 (2261; 3027)	71.6 (63.8; 79.4)	0.1	9139.2 (6994.4; 10,361.7)	72,526		
				80 %	5303 (4058; 6592)	3957 (3391; 4547)	57.3 (56.8; 57.8)	0.1	9139.2 (6994.4; 11,361.7)	58,021		
			RSV Maternal Vaccine + Nirsevimab	60 %	3977 (3044; 4944)	5283 (4552; 6089)	42.9 (42.7; 43.2)	0.1	9139.2 (6994.4; 11,361.7)	43,516	72,526	March–July
				40 %	2651 (2049; 3307)	6608 (5694; 7617)	28.6 (28.5; 28.8)	0.1	9139.2 (7061.9; 11,398)	29,010		
				20 %	1326 (1020; 1647)	7934 (6800; 9116)	14.3 (14.3; 14.3)	0.1	9139.2 (7031.2; 11,355.6)	14,505		

Notes: *Maternal immunisation with 6 months of protection (if infants are immunised the month of birth); Nirsevimab with 6 months of protection (if infants are immunised the month of birth); or Maternal immunisation with 6 months of protection and Nirsevimab with 6 months of protection (if infants are immunised the month of birth).
Doses administered: The total number of doses administered, equal to the sum of all birth_month_covered_by_vaccine. If coverage is 100 %, then this number equals the total number of eligible newborns.
95 %CI: lower 95 % confidence interval and upper 95 % confidence interval.
** Birth month covered vaccine (counts): The number of newborns born in each of the birth_months_eligible_for_prophylaxis. Where Birth months eligible for prophylaxis (months): Calendar months during which infants are born who are eligible to receive prophylaxis, based on the strategy's timing (e.g., seasonal protection window).

63.8–79.4) of RSV-ALRI.

Efficiency per 100,000 doses administered was comparable across countries within each strategy, assuming equal effectiveness and uptake. In the Dominican Republic, the estimated efficiency for long-acting mAb was 9792 (95 %CI: 7526; 12,151) RSV-ALRI cases averted per 100,000 doses, modestly higher than that of maternal vaccination at 8704 (95 % CI: 6704; 10,827), and the combined strategy at 9139 (95 %CI: 7017; 11,408). Identical point estimates were observed for Mexico and Paraguay, reflecting consistency and small absolute differences between strategies (Table 3) (See "Supplementary Results").

4. Discussion

The variation of RSV patterns in the Americas presents challenges for new RSV prophylaxis, underscoring the need for country-specific seasonality analysis. This study provided insights into the optimal timing of immunisation strategies to protect against RSV infection across the region and quantified the impact of the RSV interventions by climate regions.

Based on data collected over 10 years (prior to the COVID-19 pandemic and the introduction of RSV preventive products) from LAC countries through sustainable respiratory surveillance and standardised protocols, we identified consistent patterns of RSV activity. Most countries fall into tropical or subtropical climate zones, with key differences in RSV onset and duration within these regions. Although countries at similar latitudes shared similar RSV patterns, we observed subnational variability in line with other previous studies [44,45] and tropical countries may benefit from subgrouping to better understand factors influencing RSV seasonality [20,22,24,46]. The observed variation in RSV seasonality across countries likely reflects differences in latitude, climate, and local surveillance capacity, as well as socioeconomic and healthcare access factors. These potential drivers, which were not accounted for in the present analysis, may partly explain the heterogeneity in timing and duration of epidemics across the region.

RSV activity in the tropics displayed year-round patterns, with varying onset by geographic subregions. Only some tropical climate countries presented multimodal or year-round RSV epidemics, those being primarily Caribbean countries. Central American countries began their season by July–August, aligned with previous studies [20]. Overall, RSV activity lasted five months in tropical countries. In line with the amplitude of the RSV peaks in weeks, from EW 5 in Saint Lucia to EW 47 in Nicaragua, only tropical climate countries presented multimodal RSV epidemics from 2010 to 2019. In contrast, we observed differences in RSV patterns in subtropical countries. The seasons were the shortest in this group, at three to four months. Countries with similar latitudes were likely to have similar RSV onsets as those observed in temperate climates.

Our cross-sectional analysis provided implications for immunisation strategies. Seasonal administration of nirsevimab was more effective at averting RSV-ALRI cases than maternal vaccination or their combination across all climate zones. However, both strategies offer substantial benefit and could reduce the burden of RSV-ALRI among infants in the three countries. In temperate climates, protection is straightforward for birth cohorts born before or during RSV epidemics. This aligned well with recent national recommendations for newly introduced RSV products in Southern Cone countries [3,12,13]. However, more understanding of the impact of partial coverage with nirsevimab or maternal vaccines for infants born in months like June–July (Northern Hemisphere) or January–March (Southern Hemisphere) may be beneficial. The added value of combining maternal vaccination and nirsevimab remains unclear and should be assessed by weighing potential healthcare savings against added costs of dual intervention. In tropical and some subtropical countries, administering maternal vaccine and nirsevimab year-round could protect all monthly birth cohorts. The main challenge is providing comprehensive coverage to children born early in the year, as they are still exposed to RSV later in the season once the six-month protection diminishes and at risk of developing severe RSV infections. Future childhood vaccines delivered at six months could provide coverage to at-risk newborns no longer protected from maternal vaccines. Alternatively, we suggest a combination of available strategies where additional nirsevimab grants coverage to at-risk newborns no longer protected could be beneficial, but more studies should assess the cost-effectiveness and feasibility. While maternal vaccines might be affordable in the future through the Revolving Fund, the cost of mAb remains high, which could limit the introduction in preventive campaigns [4,7,15].

Upon analysing RSV seasonality and intervention protection by climate, we quantified the potentially averted RSV burden in the community through different uptake scenarios of passive immunisation in three countries with different climates. Our findings -showing ~55 % to 76 % of cases averted at a 100 % of theoretical upper threshold- are consistent with estimates from Italy (~37 %–72 %) in the same target age group, despite differences in geography, seasonality and uptake [16]. In the temperate climate country, a Nirsevimab campaign averted ~172,700 ALRI-RSV cases among 0- < 12 months infants— with 100 % uptake, representing ~40,800 to ~47,000 additional cases averted relative to the maternal vaccine or a combination. When 80 % of the monthly births were covered, the efficiency per 100,000 doses administered remained similar across all uptake scenarios, with a lower number of averted cases. In the tropical Dominican Republic, Nirsevimab led to a 69.3 % reduction in RSV-ALRI cases, with a modest additional ~2000–2550 cases averted relative to the other interventions. Lastly, in Paraguay, a combined strategy resulted in a 71.6 % reduction in RSV-ALRI cases, representing only ~300–790 additional RSV-ALRI cases averted relative to maternal vaccination or nirsevimab. We acknowledge that assuming full coverage represents a theoretical scenario. By incorporating multiple coverage levels (80 %, 60 %, 40 %, 20 %), we provide a practical range and demonstrate that reduced uptake results in proportional decreases in averted cases and an increase in residual cases' susceptibility. Although we did not consider waning immunity or indirect effects, it enhances the robustness of our estimates and underscores the importance of maintaining high coverage and robust surveillance to inform RSV immunisation strategies across diverse epidemiological contexts.

Despite comparable overall burden averted across various strategies, efficiency per 100,000 doses differed only modestly, with long-acting monoclonal antibodies (mAb) showing marginally higher efficiency than RSV maternal vaccination. These small differences highlight the importance of timely initiation of immunisation and the impact of each strategy based on a comprehensive analysis of RSV seasonality and duration of interventions. Strategy selection may be guided more by feasibility, cost and anticipated uptake than by per-dose efficiency alone. While these findings guide selection of interventions, they should be interpreted with caution and always alongside cost-effectiveness analyses.

Similarly, a study by Li et al. assessed the proportion of RSV hospitalisations averted, represented by the "relative effectiveness of the intervention" by comparing year-round or seasonal campaigns in low- and middle-income countries with defined RSV seasonality [40]. While the analysis did not examine interventions for newborns aged 6 to 12 months or consider a combined RSV preventive strategy, its findings align with ours. A year-round approach for nirsevimab could be beneficial in temperate countries, where seasonal administration may fail to protect infants born early in the season and those beyond the initial six months of passive maternal antibodies. While both studies used the available maternal vaccine efficacy from clinical trials as an equivalent of effectiveness [8], we applied the intervention to all ALRI-RSV cases and did not include hospital admission rates. Our findings complement those reported by Li et al. who focused on more severe RSV presentation.

RSV climatic variations underscored the importance of surveillance in tailoring the timing and extent of annual campaigns. RSV seasonality informs the selection of interventions with the most impact. Public

health initiatives can enhance prevention efforts for newborns by defining optimal windows.

This study is not without limitations, including surveillance data and methodological limitations, assumptions and extrapolations, exclusion of key factors, and regional considerations. This study primarily analysed pre-pandemic RSV seasons and excluded the potential impact of COVID-19 on RSV dynamics and population structures [47], recognising that RSV seasonality has gradually reverted to pre-pandemic patterns [48]. Further analysis incorporating surveillance data since 2022 could capture potential shifts due to the pandemic. While the SARI case definition may overlook certain RSV cases, especially in infants presenting without fever, population-level trends in seasonality are consistently reflected through aggregated sentinel surveillance data, in accordance with global standards on integrated respiratory virus surveillance [29]. In addition, regional data gaps, particularly in the Caribbean before 2019, limit the generalisability of our findings. Nonetheless, the strengthened laboratory capacity as a result of the COVID-19 pandemic regional response and the expanded RSV molecular detection, provide better surveillance characterisation for future RSV seasonality analyses [49].

The models used to assess RSV seasonality—WHO average curves, MEM, and other time series approaches—lack a "gold standard" and have well-documented limitations [28,33,34]. While widely used, these may not capture the full complexity of RSV dynamics, especially in tropical regions with multimodal epidemics. To mitigate this, we applied inclusion criteria; still, methodological assumptions such as using averaged curves or RSV percentage of positivity as parameters may oversimplify regional variability.

While we assumed that climate regions based on latitude could reliably predict RSV transmission zones based on previous studies [21,22,31,46], this may not apply everywhere, and other approaches could additionally identify subgroups of countries with similar seasonality [46]. Indeed, our study showed that characterising countries as tropical might be insufficient, as we observed both tropical and subtropical patterns within this group. Likewise, we did not account for factors influencing immunoprophylaxis, such as vaccine and monoclonal antibody effectiveness, waning immunity and effectiveness over time, immunisation coverage, prematurity rate and other risk factors for RSV infection in newborns. Our estimated proportions of averted ALRI-RSV cases align with the reduction in Italy, despite limiting severity comparisons [16]. Disease burden estimates for RSV, particularly among newborns, were used from publicly available literature [1] to model the hypothetical impact represented by potential ALRI-RSV cases averted among three birth cohorts and understand the implications of analysing by different climates. Likewise, we used maternal vaccine efficacy and mAb effectiveness to estimate combined effectiveness of interventions [16]. While our findings are valuable in informing policy for introduction of RSV prophylaxis, the impact model would benefit from using annual regional real-world effectiveness combined.

In the absence of local data, averted burden was estimated from published ALRI-RSV incidence risk for upper-middle-income countries as a proxy. Socio-economic and healthcare access barriers may underestimate the burden. Since RSV products were not introduced during the study period, we analysed a scenario-based model rather than a projection of actual product impact during the first period of life. While we accounted for lower immunisation uptake scenarios; the real-world number of averted cases may be lower than our estimates. Dynamic modelling framework could capture transmission dynamics, including herd immunity, waning protection and inter-seasonal effects of nirsevimab administration in population susceptibility or risk in the next season. In our study, herd immunity was expected to be limited, and essentially absent with passive immunisation; therefore meaningful differences between static and dynamic models are not expected [40]. This study's strength is understanding the implications of regional and temporal variability of RSV seasons in preventive strategies. A key assumption is that RSV seasonality is sufficiently stable for 2010–2019 data to represent transmission patterns expected post-introduction. Subregional RSV seasonality variations and interactions with other respiratory viruses (e.g., influenza, SARS-CoV-2) were excluded, which may affect the timing and strategy of immunisation campaigns, especially after COVID-19. While the current understanding of RSV seasonality in tropical regions has increased, further research is needed on critical factors influencing seasonality. Namely, understanding the relative impact of the number of peaks and the duration of multimodal epidemics is key. This is especially pertinent given the challenge of ensuring that current immunoprophylaxis strategies successfully cover the at-risk population amidst year-round or multimodal viral activity.

The complex relationship between immunisation campaigns and RSV seasonality, particularly in tropical and subtropical regions where RSV circulates year-round, emphasises the importance of aligning immunisation product deployment plans with local RSV epidemiological patterns. To address these complexities, advanced models with real-world effectiveness are needed to evaluate and fine-tune strategies that combine immunisation approaches targeting tropical countries. These models should be easily replicated and supported by robust, country-specific RSV surveillance data that could feed into economic burden and cost-averted analysis later.

Achieving adequate RSV protection ultimately requires aligning immunisation efforts with the most up-to-date regional RSV seasonality data. Tailored strategies, such as leveraging surveillance data to customise the timing of maternal vaccines and monoclonal antibodies, can enhance protective coverage. This is particularly critical when these interventions are adapted to local transmission patterns and birth cohort dynamics to maximise the benefits.

CRediT authorship contribution statement

Paula Couto: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Harry Campbell:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **You Li:** Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Marc Rondy:** Data curation, Funding acquisition, Writing – review & editing. **Juliana Leite:** Data curation, Writing – review & editing. **Angel Rodriguez:** Data curation, Funding acquisition, Writing – review & editing. **Jairo Mendez-Rico:** Data curation, Writing – review & editing. **Francisco Nogareda:** Data curation, Writing – review & editing. **Jorge Jara:** Data curation, Writing – review & editing. **Andrea Vicari:** Funding acquisition, Supervision, Validation, Writing – review & editing. **Harish Nair:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2025.127934.

Data availability

Data will be made available on request.

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